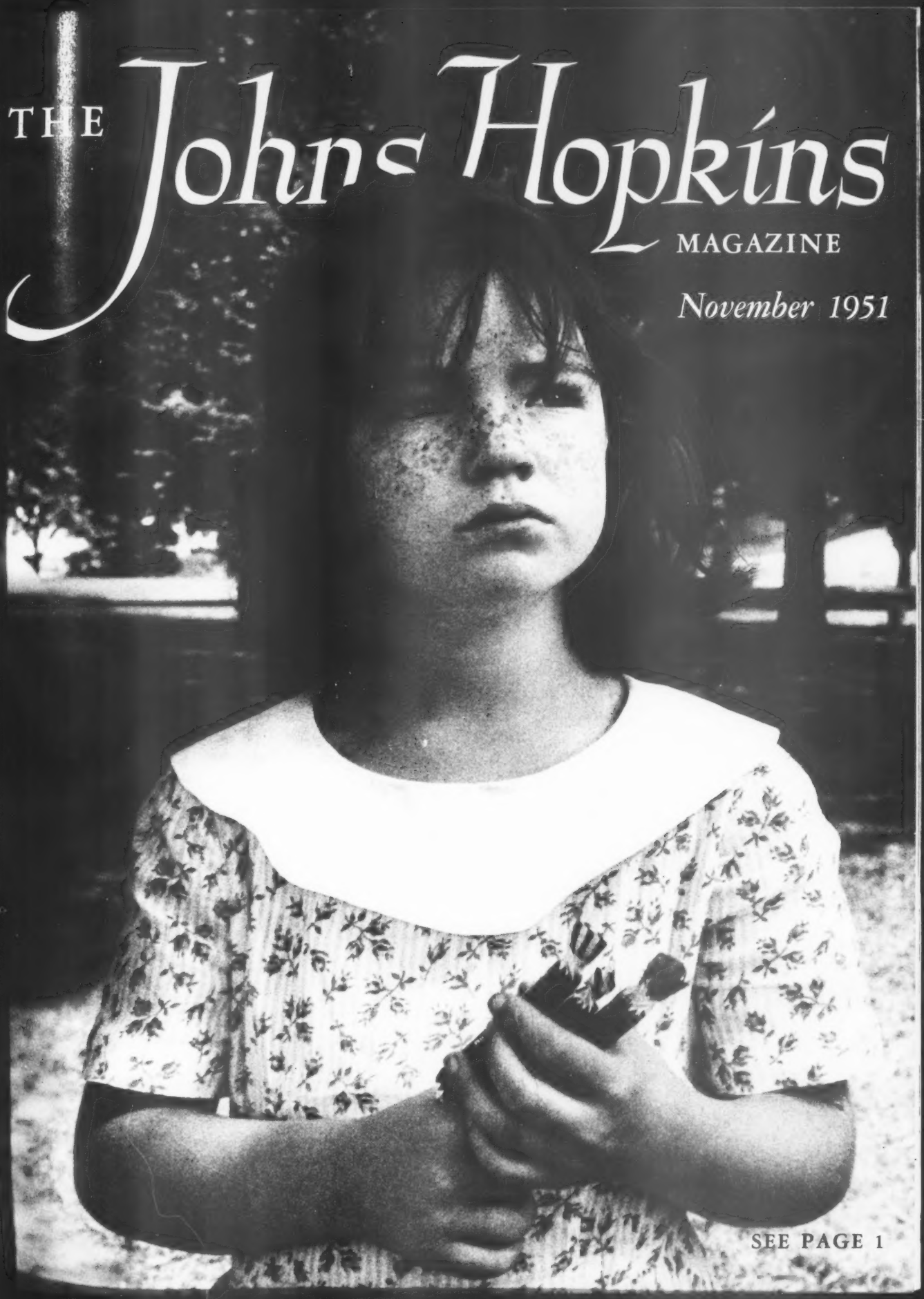
THE Johns Hopkins MAGAZINE

November 1951



SEE PAGE 1

GILMAN HALL AT JOHNS HOPKINS

In the vigor of its free institutions lies America's greatest strength . . . and the hope of all humanity. To do his part toward keeping them strong . . . to have a part in making them even stronger . . . is the responsibility—indeed the privilege—of every free man.

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THE Johns Hopkins MAGAZINE

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The Cover

The name of the young lady with the bubble gum on this month's cover is Gretchen. Gretchen was a student in the Homewood Demonstration School at Hopkins last summer. The Johns Hopkins Magazine spends a week with Gretchen and her first-grade classmates and teacher, in the Homewood Demonstration School picture story beginning on Page 12.

Photo by Jack Engeman

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Far-ranging weapons have been developed

at a closely guarded Johns Hopkins laboratory

GUIDED

Official U. S. Navy Photo

A large ram-jet, developed by the Johns Hopkins University's Applied Physics Laboratory and its associate contractors, is launched at the Naval Ordnance Test Station at Inyokern, California. It attained a velocity "far into the supersonic range." Like other ram-jets, it must be boosted to near the speed of sound before the ram-jet engine works successfully.

MISSILES

MR. TRUMAN was addressing Democratic Party leaders in San Francisco, during the week of the signing of the Japanese peace treaty.

"It is fantastic," he said, "what can happen with the use of the new weapons that are now under construction in this country . . . weapons which are fantastic in their operation.

"I hope," Mr. Truman added fervently, "we will never have to use them."

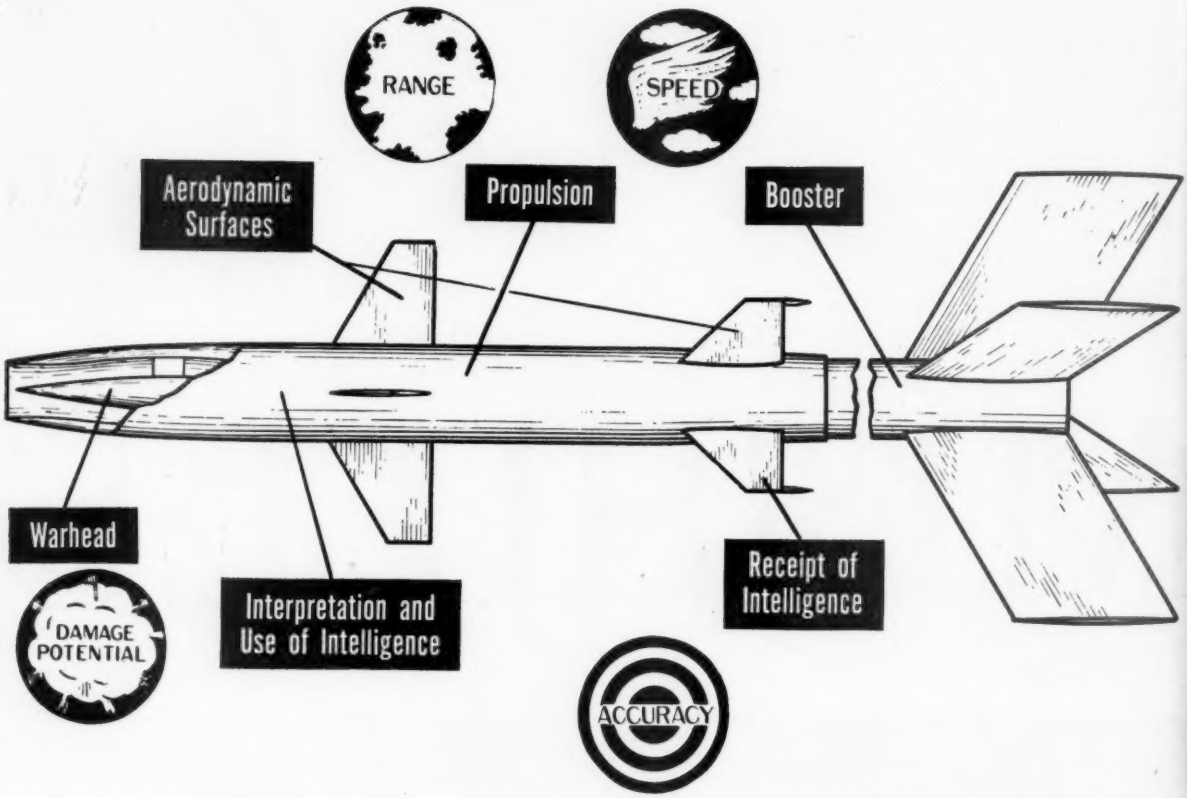
A week and a half later, the President confirmed at a press conference in Washington that one of the fantastic weapons to which he referred was the guided missile.

Several weeks earlier, at Pomona, California, a ground-breaking ceremony had taken place. It had been attended by high military and civilian officials. Rear Admiral Malcolm F. Schoeffel, representing the Secretary of the Navy, made an address. "The vast amount of work . . . in the last six years," he said, "is about to come to fruition." Admiral Schoeffel was speaking of the work that had been done on the development of guided missiles. The ground was being broken for a plant to mass-produce them.

A few years ago, sailors began reporting for a training course at the Johns Hopkins University's Applied Physics Laboratory. They were mostly men with Navy ratings involving gunnery, electronics, or machine skills—the first trainees in a program which has been running steadily ever since. Their presence at the Hopkins laboratory, a service publication noted recently, is a sign that in these dangerous days the Navy is "losing no time." The men were reporting to the Applied Physics Laboratory for advanced training in a highly mysterious field: how to launch, guide, and service guided missiles. The Navy felt the Applied Physics Laboratory was the ideal place for its men to learn these things; for in the development of such instruments the Laboratory had long been preeminent.

THE Applied Physics Laboratory (APL for short) is a closely guarded division of the Johns Hopkins University at Silver Spring, Maryland. Much of the work it has accomplished since its establishment in 1942 has never been divulged; it is still on the super-secret list. Visitors are not permitted at APL. No one can pass the armed sentries in its reception lobby without a special badge, furnished only to persons having specific business beyond that point. Some of its offices and workshops are completely out-of-bounds to everyone except an authorized handful of research men.

During World War II, Hopkins scientists at APL developed a weapon whose contribution to



Johns Hopkins Applied Physics Laboratory

A TYPICAL GUIDED MISSILE, without platform equipment, shows the major functional components of the weapon. Circular symbols indicate what tactical purpose is served by each of the labelled parts of the missile: booster builds up missile's speed, for instance.

bringing the war to a speedy and successful conclusion is generally regarded as second only to the A-bomb. This weapon, the proximity fuze, was a tiny radio receiving and sending set which would uncannily detonate a projectile at the precise distance from a target at which its fragments would be most damaging. Against Japanese planes in the Pacific, its record was impressive to a degree realized by few Americans. In the Second Battle of London, in the Battle of the Bulge, and in the defense of Antwerp, its role against German buzz bombs was probably a decisive one.

Since the war, the focus of attention and abilities for many scientists at APL has been guided missiles. These scientists have been busy with projects which until a few years ago would have been dismissed by most people as more properly belonging in a Buck Rogers comic strip than in a great university. They have designed rockets; they have improved upon their achievements with another wartime project—supersonic weapons propelled by ram-jet engines; they have packed German V-2's and APL-designed Aerobee rockets jam-tight with incredibly delicate instruments and shot them scores of miles above the earth to gather information about the upper atmosphere, rocket performance, and the hundreds of details needed in the development of missiles. Now, their long years of work are bearing fruit. APL, said Admiral Schoeffel at the California ground-breaking ceremony, "has conducted or directed the mass of research that has gone into the missiles now scheduled to be built at this plant."

EXACTLY how far the development of guided missiles in this country has progressed is a story which cannot, of course, be told. This article, it should be understood, does not pretend to reveal "inside information"; to do so, even if such information were in the possession of the editors (which it is not), would be a grave disservice. Nor will speculation be indulged in; although it is perfectly permissible for anyone to hazard guesses, on the basis of facts which have been cleared by military-security authorities, to do so in a magazine published by the institution under whose direction a large part of America's guided-missile development has taken place would be dangerously misleading.

The material which follows, therefore, is based closely upon—and, in fact, sometimes taken directly from—the generally known factual information compiled and published, with the full authorization and approval of military

Convair Photo

BREAKING GROUND for plant to mass-produce guided missiles, Rear Admiral Malcolm F. Schoeffel (with spade) said Hopkins' Applied Physics Laboratory was responsible for the mass of research making production possible at this new plant.

Official Department of Defense Photo

NAVY TRAINEES learn to service and operate guided missiles at Hopkins. Here they observe ram-jet in simulated flight. Man in center regulates fuel.

Official U. S. Navy Photo

TO BOOST SUPERSONIC MISSILES, rocket above was built for APL's guided-missile program.

security officials, by Johns Hopkins scientists, notably Dr. Ralph E. Gibson, director of APL, and Dr. Wilbur H. Goss.

LIKE their forerunners, guns and airplanes, guided missiles may be used for offense or defense. While missiles for offense may be very spectacular and important, missiles for defense against powerful air attack have a special appeal in the promise to readjust (to some extent) the balance between offense and defense which was so badly disrupted at the end of World War II.

Modern warfare has developed to such a point that, if an attack ever comes against the United States, it will be essential that we be able to meet it *fast*. "We shall soon no longer have time even to think," Dr. Gibson has said. "We shall have to base our defense on versatile, automatic, high-speed devices which we have endowed with intelligence and power to *act for us* to destroy the attackers or strike a sudden and paralyzing counterblow."

Against the high-flying, fast-moving airplanes that would be used in an attack on America today, even extremely high-performance anti-aircraft guns would probably be inadequate. Their limitations, both in range and in speed, are too great to be able to cope successfully with an attack by high-altitude, swift-moving bombers.

Suppose, for example, that an enemy plane is flying toward Philadelphia at six hundred miles an hour (not an excessively high speed, in these days of faster and faster flight). Six hundred miles per hour is 880 feet per second. Suppose, further, that this plane is being attacked by an anti-aircraft gun; the average time of flight of the shells from this gun to the target, let us imagine, is fifteen seconds. Here is what would happen:

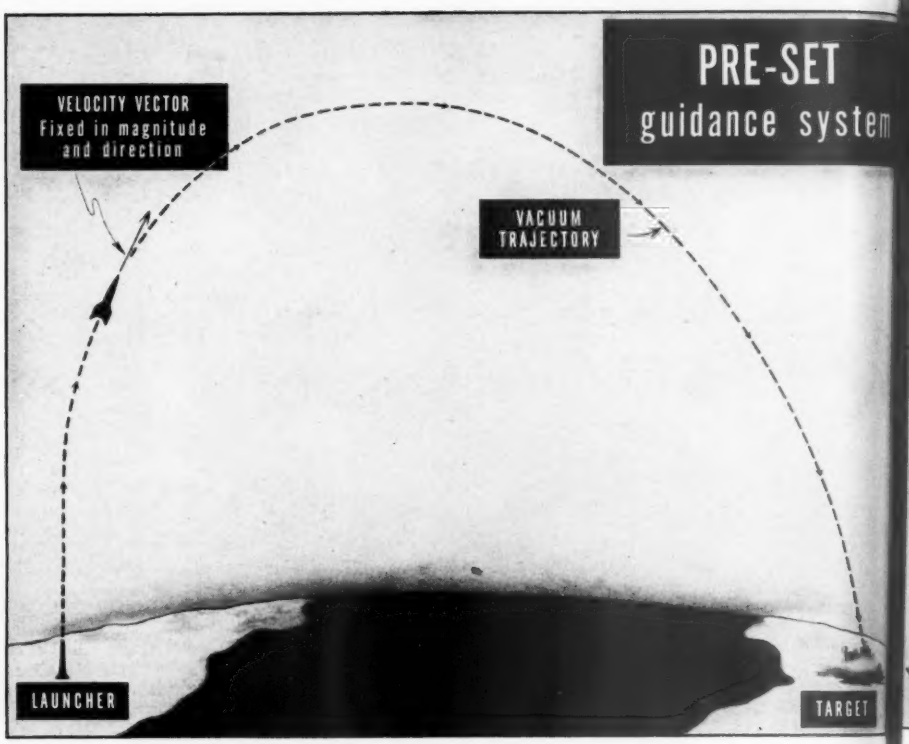
Between the moment that the shell leaves the gun and the time it arrives at the point of aim, the bomber will have traveled 13,200 feet—*two and one-half miles*—in just those fifteen seconds. The shell is, of course, not aimed at the bomber but at a point where it is expected to be fifteen seconds after firing. If, during those fifteen seconds, the bomber's pilot has changed his course as little as one-half degree, he will miss the anti-aircraft shell by 106 feet. In order for the shell and the bomber actually to collide, the pilot would have to fly his plane with an accuracy of one part in ten thousand!

Suppose that guns are available which give the shell an average velocity of three thousand feet per second during the arbitrarily chosen flight time of fifteen seconds which was used in the example above. In fifteen seconds, the shell would travel forty-five thousand feet. But if the plane were flying at an altitude of forty thousand feet, it could be only twenty thousand feet—less than seven thousand yards—away from the gun, longitudinally, for the shell to be able to reach it. It would take the bomber less than twenty-three seconds to cover that distance, and to appear directly above the anti-aircraft gun itself.

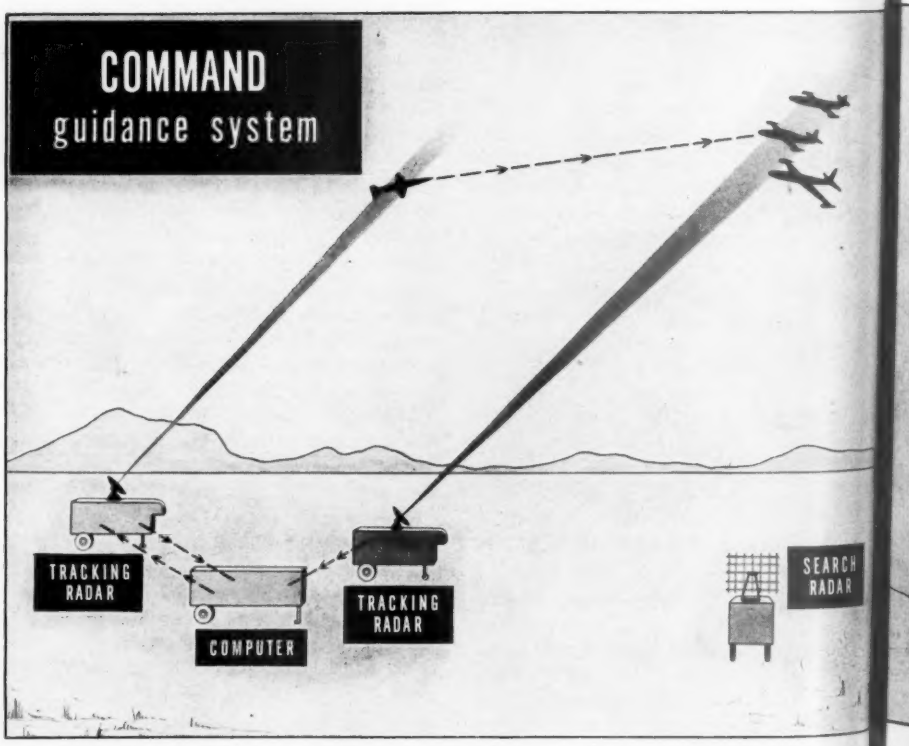
But let us imagine that somehow—perhaps by adding a propelling system to the anti-aircraft shells to sustain their flight, or by adding wings to them, or by increasing the muzzle force of the

Text continued on page 8
Overleaf: Four ways of guiding missiles

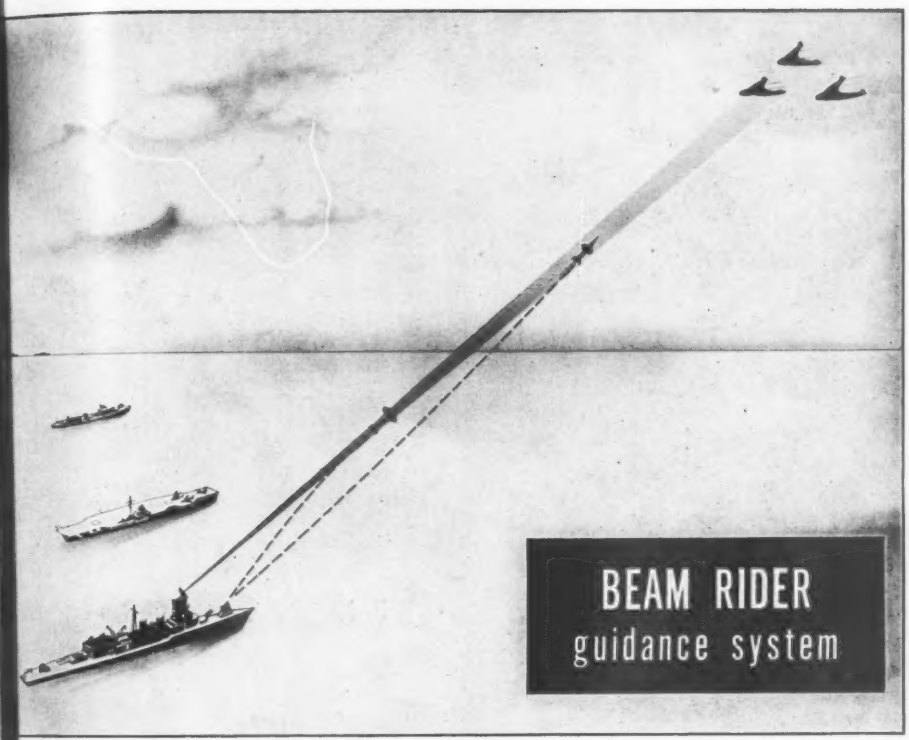
Guiding Missiles



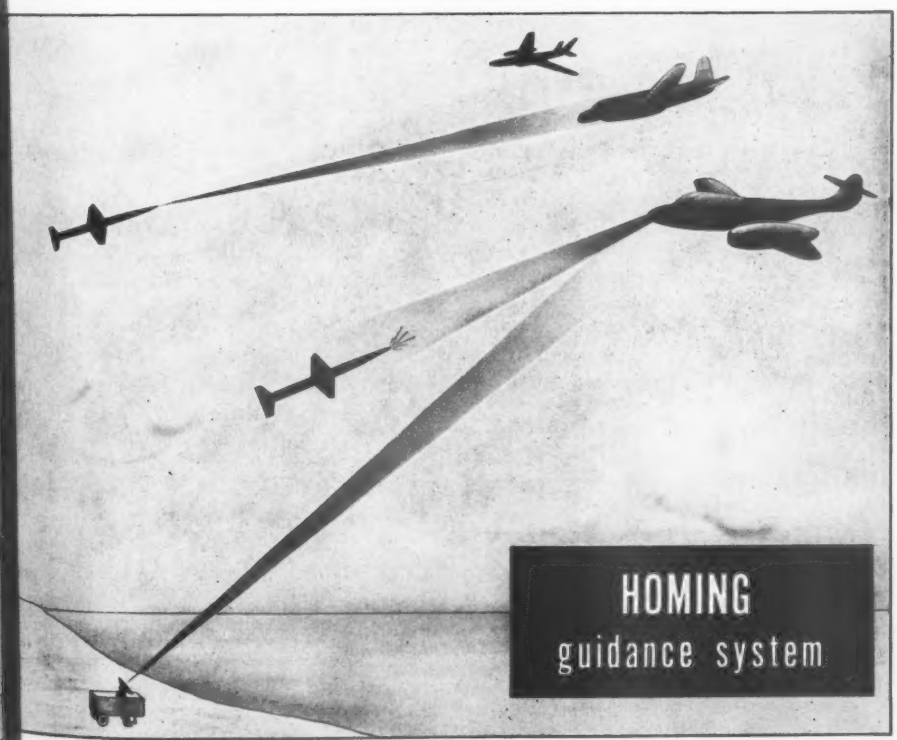
In pre-set guidance, the missile is given "where and whither" data at the launcher, and no further information is imparted after it is launched. Missile nevertheless carries such instruments as gyros, gyro compasses, altimeters, and velocity meters to help it "sense" its path through the atmosphere.



In command guidance, a ground station tracks both the missile and the target. It computes what adjustments should be made to the missile's course and then transmits instructions to the missile which cause it to alter its course accordingly.



In beam-rider (or way-following) guidance, an artificial path —such as a radar beam tracking the target—is marked out in space. Missile has a mechanism for sensing its position continuously with respect to the axis of this path, knowing when it deviates and correcting its course accordingly.



In homing guidance, a missile must be still more intelligent. It receives a directional signal directly from the target, adjusting its course to bring about a collision. Thus the missile recognizes its quarry and goes after it.

Drawings from Johns Hopkins Applied Physics Laboratory

guns—we *could* increase their range. What would that enable us to do? Frankly, not a whole lot.

Since it is highly unlikely that an anti-aircraft gunner (unless he is some sort of superman as yet undiscovered in the ranks of the Armed Forces) can fire his gun so accurately that he will invariably hit his target on the first try, he will usually need to shoot a number of rounds of ammunition at the incoming plane before he hits it. If the gunner fires a round of ammunition, then waits ten seconds to observe his fire, then fires again, what would happen? Even if the plane were moving as slowly as 410 miles per hour, an anti-aircraft gunner firing shells which travel at 615 miles per hour could get in only three shots at the plane before it appeared over his head in Philadelphia. If, on the other hand, the shell could be made to travel at the supersonic speed of 1640 miles per hour, say, he could take six shots at the attacking plane between the time it passed Atlantic City or New Brunswick, New Jersey (each some sixty miles away) and the time it reached Philadelphia.

If Philadelphia is to be truly protected against this bombing attack, the bomber must be shot down at least as far away as Hammonton, New Jersey (halfway between Philadelphia and Atlantic City) or, if the attack is coming from the north, at least as far away as Trenton (halfway between Philadelphia and New Brunswick). With the 615-mile-an-hour shell, only one round could reach the plane before it got to Hammonton or Trenton; with the supersonic shell, three rounds could reach the plane before it passed the thirty-mile mark at these cities.

All this, of course, presupposes many things which are not likely to happen, at least not in a real attack. The plane may simply be making a feint at Philadelphia; by the time an anti-aircraft shell reaches a point on his predicted course from Atlantic City to Philadelphia, the attacker may very well have veered south to Washington or north to New York, completely out of the shell's path. Since anti-aircraft shells of the power and range of those imagined in these examples would necessarily be very high-priced articles, it seems rather pointless to expend them on behalf of what would probably be the losing side of a guessing game between Philadelphia's defenders and an enemy pilot. Pointless, that is, if something better can be used.

This "something better" is, obviously, an urgent need: a weapon which can do some thinking of its own; which does not simply travel undeviatingly on a course determined at the time of its firing, toward an object which probably will not be in its path anyway by the time it reaches its intended destination. Something is needed which can follow its target to the kill, no matter how much that target twists and turns, no matter how clever the target's pilot may be. That "something" is the guided missile.

EASILY said. The creation of such a missile, however, is something else again.

The information which scientists must have in their possession before building a guided missile is staggering in its volume and detail. Years ago, APL scientists set about the gigantic task of gathering it.

What kinds of motion would missiles be called upon to execute? An analysis of these needs gave the scientists an idea of the primary requirements for the missiles' maneuverability, stability, airframe strength, and so on. From this came an idea of the specific individual problems which would have to be solved: how to design airframes, how to solve the difficulties of lift and drag, how to figure and deal with pitching and rolling, how to work out changes in center of pressure—and countless others.

At the beginning, most of APL's studies were carried out with free-flying rockets themselves, shot through the air at test fields on the Jersey coast. These rockets were filled with instruments which, from the time the craft left their launching platforms until they plummeted into the sea, telemetered (sent by radio signals) their observations about what goes on when a missile pursues its speedy course through the atmosphere. Later, when a great supersonic wind tunnel was completed under APL's supervision close to the air supply of an idle blast furnace at Daingerfield, Texas (*see photograph, Page 30*), measurements were made with models there and checked through telemetered observations from actual rockets in free flight.

HAVING worked out the basic problems of flight itself, the scientists concerned with developing guided missiles must next determine how to enable the weapons to perform what is their unique and valuable function: guiding themselves.

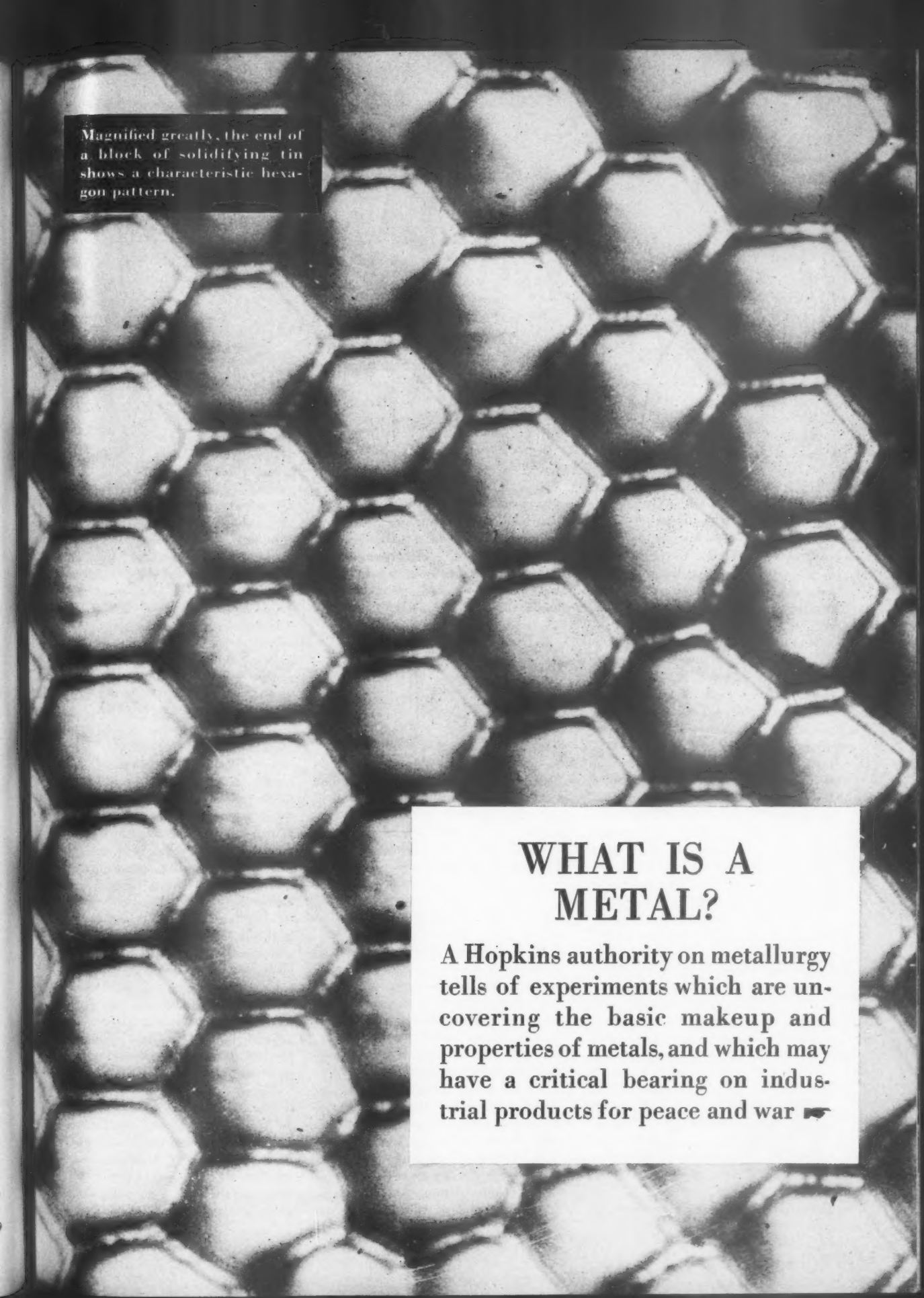
Giving the missile its intelligence—the ability to know where it is and where it is supposed to go—could be done in several ways. (*The drawings on Pages 6 and 7 of this issue illustrate four of the many possible guidance systems.*)

Simplest—and requiring the lowest "intelligence" on the part of the missile itself—is the pre-set guidance system. Accuracy and speed may be combined in a shell if the gun from which it is fired is long enough. The V-2, a typical ballistic rocket, is an example of such a system. It is accelerated for a period of nearly a minute, and its velocity rises to more than five thousand feet per second by the time the missile reaches the upper atmosphere where the aerodynamic drag is reduced to a negligible point. During this period the missile is under control from the ground so that when it reaches a given point, its velocity and direction of motion are accurately determined. From then on, the propulsion is turned off, and the missile follows a free trajectory calculated to bring it to the target. The accuracy depends on how well the velocity vector and the position in space were determined when the rocket motor was cut out. The V-2, thus, is essentially a gun with a "barrel" approximately 100,000 feet long. It extends the idea of gun ballistics without having many characteristics of an interceptor and hence is hardly typical of the modern guided missile. For truly versatile guided-missile defense, higher orders of intelligence must be incorporated into our guided weapons.

To provide this higher order of intelligence, links must be furnished between the missile and its masters which can be maintained throughout the missile's flight. These links, usually, are set up through electromagnetic radiation; light, long-wave radio, and continuous or pulsed microwave radar are some of the methods which might be used.

First, there is the command-guidance system, in which a ground radio or radar station tracks both the missile and the target. A computer, set up in conjunction with the radar station, automatically figures what adjustments must be made in the missile's course in order to cause it to hit the target, and then transmits instructions to the missile which cause it to alter its course accordingly. The equipment which the

Continued on page 30



Magnified greatly, the end of a block of solidifying tin shows a characteristic hexagon pattern.

WHAT IS A METAL?

A Hopkins authority on metallurgy tells of experiments which are uncovering the basic makeup and properties of metals, and which may have a critical bearing on industrial products for peace and war ☛

WHAT IS A METAL?

By ROBERT MADDIN

With illustrations by the author

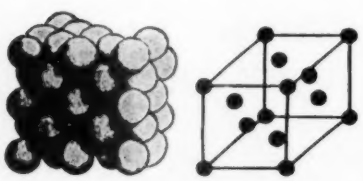
TO the average man on the street, a metal is a smooth, hard substance whose properties are permanent except for occasional corrosion or deformation to a different shape.

Closer examination, however, reveals a granular structure. In it individual grains can vary in size six orders of magnitude. A still closer examination, with the aid of x-rays, brings to light an orderly array of atoms within each grain.

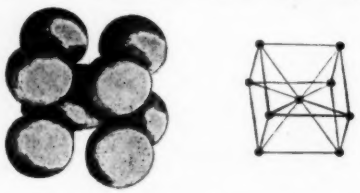
Careful study has shown that in general, the atoms of metals are aligned periodically in three mutually perpendicular directions—much the same as if cork balls were to be packed close to one another and stacked in the hollows made by the close packing. The regularity of the atomic stacking, however, is not perfect; many positions are not filled, many atoms are not in their right places. These errors in stacking are termed imperfections, and it is thought that because of them, metals vary in behavior with respect to certain properties such as mechanical behavior and diffusivity.

Since the atoms are in constant motion, these imperfections are constantly being healed; at the same time, new imperfections are being formed. Diffusion processes are continually going on. Instead of conforming to the usual static conception customarily held for a solid, there is something nearly as dynamic as a liquid.

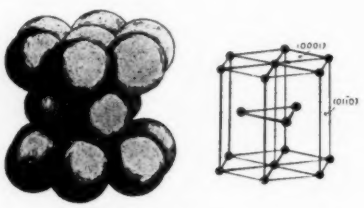
There are, in general, three ways in which the atoms of metals are packed in the solid state. Metals such as copper, aluminum, nickel, lead, gold, silver, palladium, platinum, and others are classed as "face centered cubic" (close-packed cubic) metals. In this crystal structure, as seen here,



there is an atom at each corner of the cube and one on each face. Metals such as iron, chromium, columbium, wulfram, tantalum, molybdenum, the alkali metals, and others are classed as "body centered cubic"; in this arrangement,



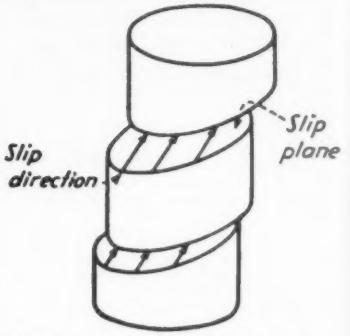
there is an atom at each corner and one in the center of the cube. Metals such as zinc, beryllium, cobalt, magnesium, titanium, and zirconium fall into the "hexagonal close packed" arrangement, illustrated thus:



Here, there is an atom at each of the corners of a hexagon and one at the center; the atoms above and below are nestled into the hollows made by those in the hexagon, so that every alternate atom is in an identical position one layer removed.

THE atoms within any one of the grains referred to earlier are, in general, arranged in one of these three arrays; however, the orientation of one grain with respect to some arbitrary reference frame and its neighbor differs. Consequently, the grains do not fit together perfectly, and the result is a boundary region or grain boundary.

When metals are subjected to stresses in the plastic region (that region where the strains are permanent), each of the grains deforms by a translation or gliding of one part of the grain over another. This gliding or slipping continues within the grain until it meets an obstruction such as a boundary. Gliding occurs on planes of atoms (crystallographic planes) and along rows of atoms (crystallographic directions), as shown thus:



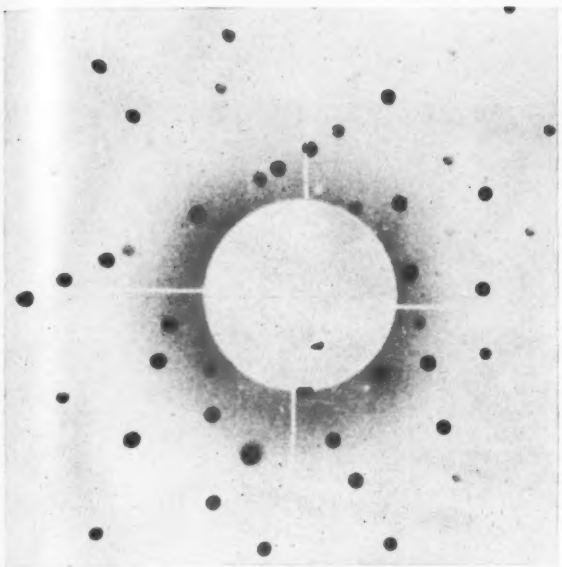
Some important phenomena are associated with the deformation of metals. For example, the stress required for yielding is increased with prior plastic deformation. This is called strain hardening. Properties such as electrical conductivity, thermal conductivity, and ease of magnetization are altered by plastic deformation.

In any aggregate of grains such as composes industrial metals, it is difficult to investigate the effect of deformation because of the interaction of the grains with one another. Consequently it has become necessary to develop techniques for isolating individual grains, or for growing single grains large enough to handle and study effectively.

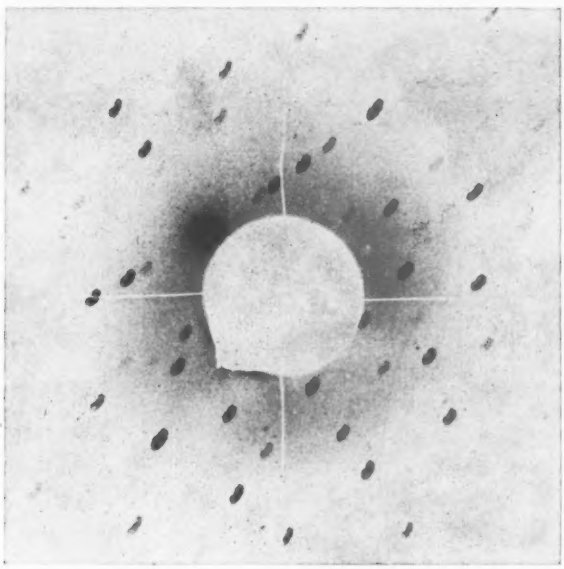
IN the metallurgy section at Johns Hopkins there are especially designed furnaces capable of growing single crystals of metals two feet long whose melting points do not exceed 1100°C. There has recently been developed at Hopkins a method for growing large crystals of the refractory metals with extremely high melting points, such as molybdenum, wulfram, tantalum, and columbium.

The Hopkins group is actively engaged in studying structural changes accompanying the plasticity of molybdenum single crystals. These investigations are sponsored by the Office of Naval Research. The increased need in industry for metals with high strength at high temperature has necessitated investigations of all the high temperature metals.

Molybdenum, whose melting point is 2625°C (4760°F), has good strength at fairly high temperatures; its ore is readily available in the United States. There are, however, certain difficulties encountered in its use as a pure metal or base metal alloy. Pure molybdenum oxidizes at relatively low temperatures.



1 AN UNDISTORTED SINGLE CRYSTAL of molybdenum is shown (*above*) in its typical structure by a Laue photogram.



2 AFTER SLIGHT EXTENSION the same crystal has been greatly altered, as seen in the marked elongation of the spots.

It is brittle at room temperature and hence cannot easily be fabricated to the finished product. The single crystal of molybdenum, however, is not brittle. On the contrary, the single grain has been extended seventy-five per cent at room temperature; it has been rolled ninety-eight per cent to a very thin sheet.

This points rather conclusively to the fact that the embrittling component in commercial molybdenum is located in the grain boundaries, since the material without a grain boundary is ductile. The problem is now narrowed down to the point where the demon in the grain boundary must be isolated and rendered innocuous, or eliminated entirely.

DURING the past thirty years there have been few investigations concerned with the structural changes which accompany the plastic deformation of body centered cubic metals. At the present time, there exist three main theories dealing with the deformation of this class of metals; however, these theories do not satisfy the observations reported in the literature.

Since molybdenum is one of the body centered cubic metals, the basic aspects of the manner in which it deforms are of tremendous importance in deriving a sound theory of the plastic deformation of this class of metals. The structural changes resulting from the gliding of planes of atoms over one another are being studied with aid of x-rays. For example, figure 1 shows a back-reflection Laue photogram of an undistorted single crystal of molybdenum; figure 2 shows a back-reflection Laue photogram of the same crystal after it has been extended less than one-half of one per cent.

The pattern in figure 1 is typical of any undistorted body centered cubic metal structure. The elongation of the spots (asterism) shown in figure 2 indicates that the relatively perfect periodicity of the atoms composing the strain-free crystal is altered by the small plastic extension. The planes of atoms over which gliding has occurred (in order to allow the metal to alter its shape) are no longer perfect planes but are slightly bent. The stress necessary to cause plastic flow within a perfect order must be increased when the structure is disturbed in some way, such as by prior plastic flow. This is a simple explanation of the phenomenon of strain hardening referred to earlier.

Of primary importance in the construction of an explanation for the plastic behavior of the body centered cubic class of metals is the determination of the crystallographic nature of the deformation process. Here, the x-ray is of tremendous importance. The glide elements, referred to earlier, are generally determined by observing the traces at high magnifications in such a manner as to resolve the traces on a projection.

IN the simple case of traces from only one set of crystallographic planes this method is accurate. In the case of molybdenum, however, where there is more than one set of traces, the observation method results in an integrated trace which may not represent the true crystallography of the deformation process. The x-ray beam, on the other hand, delineates the structural changes on an atomic scale.

By analyzing the x-ray photograms made after progressive deformation of molybdenum crystals, Dr. N. K. Chen and the writer have been able to show that what formerly were considered as traces of more than one type of plane are actually the traces of non-parallel high-atomic density planes of the same type. This very important discovery has simplified the deformation picture considerably, and it is felt that additional work in progress will aid measurably in this basic problem.

A SERIES of studies of the structural changes accompanying plastic deformation in wulfram, columbium, tantalum, vanadium, chromium, and iron is under way in the metallurgy section under sponsorship by the Office of Naval Research. With the participation of graduate students, new basic facts are being uncovered which should contribute to a more sound theory of physical plasticity.

The problem of plastic deformation of metal single crystals is being in-

Continued on page 28

Demonstration School

The story of a week in a modern first grade

Photographs for The Johns Hopkins Magazine by Jack Engeman

FOR six weeks every year, the engineering buildings at Johns Hopkins are converted into a little red schoolhouse. The big, adult-size furniture used by Hopkins students is moved into storage rooms, and in its place come small-scale desks, chairs, tables, and drawing easels. Several days later, the children and teachers arrive, and seven classes, from kindergarten through the sixth grade, get under way.

The Homewood Demonstration School is one of the most modern schools in the country, and its first grade, in which the pictures on these pages were made, exemplifies the way it goes about its work. Its twenty-two

On a shady Hopkins lawn, first graders at the Homewood Demonstration School play a fast-moving game of drop the handkerchief.

pupils are a carefully selected cross-section of first-grade children throughout Baltimore, picked by school principals and invited (with parental approval) to spend six summer weeks at Homewood at the Demonstration School. Although they may cover five months' work in the six weeks, the first-graders do not "skip" a half-year by attending the school; it is, rather, an "enrichment," or "enlightenment," experience for them.

In the Demonstration School the teachers, too, are hand-picked. They come from the Baltimore school system: they are invited to teach at Homewood, not assigned to the job. Nor can they apply for it. The curriculum is elastic, and teachers have an unusually free hand in planning their programs.

The Homewood Demonstration School has been in existence since 1921, when it was founded by the Baltimore Board of Education in cooperation with Johns Hopkins. As its name implies, it doubles as a laboratory through which teachers attending Johns Hopkins education courses may observe the latest methods of teaching in actual use.

The pictures on the pages that follow show how, for both the first-graders and their observers, it is done.

Miss Charlotte Hurtt teaches the first grade.

The teacher is Miss Hurtt

Miss Charlotte Hurtt (*left*), the first-grade teacher at the Homewood Demonstration School, is a person who truly loves her work and shows it. In return her pupils (and their parents as well) adore Miss Hurtt; the children look to her for everything from sympathy and first aid when they skin their knees playing tag to their first introduction to the art of learning to read. With parents (with whom she regularly meets), Miss Hurtt is an understanding, helpful consultant.

At the Demonstration School, Miss Hurtt's teaching talents were often put to the highest test: they were observed by some of the toughest critics in the education business, teachers themselves (*below*). She and her pupils, whether they were being observed or not, were a good demonstration of how a first grade should be run.

Class is observed by education students at Hopkins.

Teacher, parent, and pupil inspect a first-grader's drawing.

Miss Hurtt talks to Dr. Mumma of Hopkins summer-session staff.

Mr. and Mrs. Vinegar

A high point in the first grade comes when Miss Hurtt sets up her slide-film projector (with which every classroom is equipped) and tells, with pictures, the story of Mr. and Mrs. Vinegar:

Once there was a little
old man . . . and once there
was a little old woman.
They were Mr.
and Mrs. Vinegar.

Mr. and Mrs. Vinegar
went to sleep in a tree.
Just then, they fell
out of the tree.
Down came Mr. and
Mrs. Vinegar!

. . . And they lived
happily ever after.

The story of Mr. Vinegar appears in the book *I Know A Story*, copyright 1938 by Row, Peterson, and Company, with whose permission excerpts of the story have been made above.

Before they learn to read, children are shown pictures in a storybook. T
act out its parts (*above*), discuss it, relate it to their own experi

First graders learn to read and draw

Drawing: jumbo-size crayons help develop large muscles in arms.

Meaningful arithmetic: Nancy m
paper dolls with nu

Looking at book, pupils discover that the story is in the printing, and want to learn to read.

To launch reading, Miss Hurtt shows how story is composed of sentences, phrases, words.

Then children build sentences themselves.

Manual skill: Neil develops it through his carpentry.

Imagination: muddily but intently, Joan's fingerpainting builds it.

Self-reliance: with big, colorful shoe, they learn to tie laces.

With Miss Hurtt, the class goes on a field trip.

They watch a Hopkins glassblower shape glass.

They feed the fish, study lilies in campus pond.

Mickey draws pond, refreshing memory at fishbowl.

Peggy, Robert, and Rosemary learn the world is round.

They study a guinea pig, handling it carefully.

Two fascinated first-graders study a real, live crab.

They learn about the world around them

For a first-grader, the world holds endless fascination. Miss Hurtt uses every opportunity to teach her pupils about the things that make it so.

On a trip to a Hopkins lily pond, she has them count the goldfish. She carefully explains the distinction between a *lily* and a lily *pad*. When one of the children asks about water bubbling into the pond, she uses her answer as a means of telling the class about evaporation.

Every night, the youngsters have new facts to take home to their families. The world is *round!* A guinea pig is *cuddly!* A man bends glass tubes by holding them over a *fire!* The world is a wonderful place; to a first-grader, learning about some of its wonders for the first time, it seems more wonderful than ever before.

Dale and Kathy help Jerry pull on his boots.

In time with music, children "see-saw," learn rhythms.

In independent activity, they hear story records on phonograph.

And finally, they learn to live with others

Playing in the sandpile, see-sawing to music in a rhythm class, playing records but keeping the phonograph tuned low so that it will not disturb other people in the room, fetching Teacher's purse when she leaves it behind on a field trip: in ways like these, pupils in the modern first grade learn to live considerately, happily, helpfully with others.

The atmosphere is relaxed. Children have a part in planning their own activities, such as field trips. But the teacher always guides them; there is never a trace of the "anarchy" which is popularly imagined to be characteristic of newfangled school procedure. Most of all, there is friendliness; even the principal, Miss Wilhelm (*below*), takes time to join in.

First-graders cluster around Principal Kathryn Wilhelm.

Dale and Peter find Miss Hurtt's lost purse. ➤

Medal of Honor

Major General William F. Dean, of Berkeley, California—Medal of Honor. In the hard early days of the Korean War, when it was Red armor against American rifles, General Dean chose to fight in the most seriously threatened parts of the line with his men. At Taejon, just before his position was overrun, he was last seen hurling hand grenades defiantly at tanks.

General William Dean knew in his heart that it's every man's duty to defend America. You know it, too. The General's job was in Korea and he did it superbly well. Your defense job is here at home. And one of the best ways to do that job is to start right now buying your full share of United States Defense* Bonds. For remember, your Defense Bonds help keep America *strong*, just as soldiers like General Dean keep America safe. And only through America's strength can your nation . . . and your family . . . and you . . . have a life of security.

Defense is your job, too. For the sake of all our servicemen, for your own sake, help make this land so powerful that no American again may have to die in war. Buy United States Defense* Bonds now—for *peace!*

Remember that when you're buying bonds for national defense, you're also building a personal reserve of cash savings. Remember, too, that if you don't save *regularly*, you generally don't save at all. Money you take home usually is money spent. So sign up today in the Payroll Savings Plan where you work, or the Bond-A-Month Plan where you bank. For your country's security, and your own, buy U. S. Defense Bonds now!

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NEWS at Johns Hopkins

A digest of developments at the University and Hospital in recent weeks

HARMLESS EMULSIFIERS

In the processing of bread, ice cream, candy, and other important foods, the food industry uses chemical emulsifiers extensively. Some scientists have questioned the safety of using them, and the process is under careful scrutiny by several government agencies.

Last spring, at a meeting in Cleveland of the Federation of American Societies for Experimental Biology, two Hopkins medical scientists reported that the chemical emulsifiers are harmless.

In a controlled study on laboratory rats, Dr. Bacon F. Chow, associate professor of biochemistry, and Dr. J. M. Burnett, resident in pathology at the Hospital, made varying dietary tests of three different chemical compounds, known in the food industry as Tween, Span, and Myrj. Each is used in different food items to produce a better mixing of ingredients: bread, it is claimed, will remain fresh for a longer time if it contains the chemicals; in ice cream and candy, they produce creamier, smoother products.

The Hopkins scientists' report, which Dr. Chow presented at the Cleveland conference, pointed out that when the experimental diets included bulk-forming ingredients such as are normally found in the human diet, the laboratory animals remained healthy. In the experiments, the concentration of the chemical emulsifiers was far heavier than that employed in commercial practice.

Baltimore Sun

AN INTERNATIONAL SYMPOSIUM on vitamins and trace elements recently was held at the Johns Hopkins School of Hygiene and Public Health in honor of Dr. Elmer V. McCollum, professor emeritus of biochemistry and the discoverer of Vitamins A and D. Above are Dr. and Mrs. McCollum at a banquet in his honor, held in connection with the symposium.

ALUMNI NOTES

William Chambers Coker, Ph.D. '01 (Bot.), is being honored by the naming of a new building at Coker College. Scheduled for completion this fall, the William Chambers Coker Science Building will provide room for the departments of biology, chemistry, physics, and mathematics.

Robert S. Cunningham, M.D. '11, fac. '15–'25, has resigned as dean of Albany Medical College to take on additional responsibilities in his post as executive director of the Albany Medical Center Council.

Robert Frederick Loeb, fac. '20–'21, was recently awarded the honorary doc-

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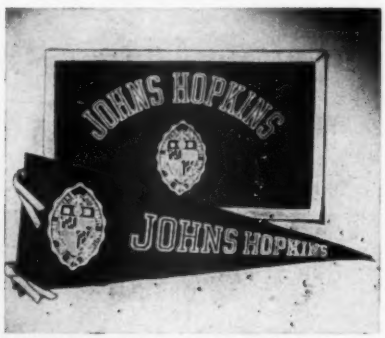

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tor of science degree by the University of Chicago for his contributions to the understanding of human physiology and disease.

LeRoy A. Wilbur, B.A. '23, has been nominated to serve as a vice chairman of the southeastern group of the Investment Bankers Association of America.

H. Houston Merritt, M.D. '26, has been elected secretary-treasurer of the American Neurological Association.

Larkin H. Farinholt, B.S. in Chem. '27, g. '27–'28, has been appointed by the Department of State to serve as scientific attaché in the embassy in London.

F. W. Ortman, Jr., '28–'30, '31–'32 (Engr.), has been named vice president in charge of personnel for Servel, Inc.

G. P. Daiger, B.E. '29, Dr. Eng. '32, has been made executive assistant in the Hoover Company's administrative office.

Harry F. Dowling, fac. '32–'33, has been appointed professor and head of the department of internal medicine at the University of Illinois College of Medicine.

William L. Doyle, M.A. '32, Ph.D. '34 (Zool.), fel. '34–'35, has been appointed by the Department of State to serve as scientific attaché in the embassy in Stockholm.

George R. Faustman, B.E. '35, has been named general factory manager of the Bendix Radio Division of the Bendix Aviation Corporation.

S. Bernard Wortis, fac. '36–'37, has been elected president of the American Neurological Association for 1951–52.

George W. Thorn, fac. '36–'42, has been awarded the Alvarenga Prize for 1951 by the College of Physicians of Philadelphia for his contributions to knowledge of the role of the adrenal cortex in health and disease.

D. C. Holly, B.S. '38, g. '46 (Educ.), now a lieutenant in the United States Navy, has been awarded the Korean Order of Merit by President Syngman Rhee for assistance in establishing the R. O. K. naval academy.

Frank A. Christoffel, Jr., B.E. '39, has been appointed assistant to the president of the Hamilton Watch Co.

George M. Brother, M. P. H. '39, has been appointed professor of preventive medicine at the Oklahoma University School of Medicine.

James Claude Thomson, M. P. H. '44, recipient of a Fulbright lectureship, is at the Medical College of the University of Tehran and in the Ministry of Health of Iran. He is on leave of absence from the University of Nanking, where he is professor of biochemistry and nutrition and head of the department of chemistry.

Howard E. Wooden, B.S. '46, M.A. '48, g. '48–'51 (Art), has gone to Athens College, Greece, where he will teach English.

James Allan Campbell, fel. '47–'48, has been appointed dean of Albany Medical College, replacing R. S. Cunningham, M.D. '11, Fac. '15–'25.

Samuel M. Wishik, M. P. H. '48, fac. '49, has been appointed professor of maternal and child health at the University of Pittsburgh School of Public Health.

John M. Wozniak, Ph.D. '51 (Educ.), has been named chairman of the department of education at Loyola University, Chicago.

DEATHS

(*Dates are 1951, unless otherwise noted.*)

Harold H. Bender, Ph.D. '07, August 16.

Henry A. Christian, M.D. '00, August 24.

William W. Dinsmore, M.D. '07, May 15.

William Dwyer, M.D. '13, June 24, 1950.

David St. Pierre Gaillard, Jr., '42–'43 (Engr.), June 9.

Samuel Goldschmidt, fac. '15–'19, August 8.

E. Read Goodridge, B. A. '23, September 16.

Clarence Flack Graham, M.D. '13, August 8.

Paul Myron Hamilton, M.D. '22, fac. '23–'24, April 9.

Louis Knott Koontz, M.A. '14, Ph.D. '18 (Hist.), August 6.

Edward Lewis Middelton, '26–'27 (Arts), August 23.

Plinio Homero Montalvan, fel. '34, January 18, 1950.

Russell La Mar Morgan, '21–'22 (Engr.), May 3, 1949.

John B. Pastore, M.D. '31, August 18.

James Edgar Paullin, M.D. '05, August 13.

Stanley Johns Reynolds, '19–'28 (McCoy Col.), September 6.

Edward A. Ross, Ph.D. '91 (Pol. Econ.), July 22.

Elenora Corbin Lubinske Schultz (Mrs. John L.), '16–'17, '25–'27 (McCoy Col.), August 27, 1949.

Grace R. Seagrave, M.D. '23, August 17.

Charles Lee Smith, Ph.D. '89 (Hist.), July 13.

Francis Di Gennaro

PRESIDENT ELPIDO QUIRINO of the Republic of the Philippines has established a tradition of holding a "fireside chat" with his countrymen on the fifteenth of every month. Recently he was away from the Philippines in order to undergo a checkup at Johns Hopkins, but he refused to let that break the tradition. Radio engineers converted his hospital room into a temporary radio studio, and President Quirino addressed his people from there.

Mary Frances Smith, g. '29–'30 (Engl.), September 1, 1950.

Johnetta Van Meter, g. '08–'09 (German), May 17.

William C. Webster, g. '89–'90 (Hist.), June 2.

THE FACULTY AND STAFF

●Among members of the Board of Trustees of the Hospital, W. Frank Roberts, president of the board, has been selected to act as a member of the seven-man Port of Baltimore Commission.

●President Detlev W. Bronk was selected as a delegate to represent the National Academy of Sciences, of which he is president, at the ceremonial session of the Diamond Jubilee Meeting of the American Chemical Society.

He received an honorary degree of doctor of laws from New York University where he spoke on "The Natural Sciences and the Law" at the dedication of the new Arthur T. Vanderbilt Hall.

●In the Faculty of Philosophy, Beulah Benton Tatum, assistant professor of education, has been elected national president of Pi Lambda Theta, a national honor society for women in the field of education.

Lt. Col. Emerson F. Hurley has been appointed professor of military science and tactics.

●At McCoy College, Francis H. Horn has resigned as dean to become executive secretary of the Department of Higher Education of the National Education Association.

Richard A. Mumma, assistant dean of McCoy College and assistant professor of education at the University, has become acting dean of McCoy College and acting director of the Summer Session.

●In the Page School of International Relations, John De Francis, assistant professor, has been elected associate editor of the *Journal of the American Oriental Society*. He has also become editor of the *Monograph Series on Languages and Linguistics*.

George M. Kahin, assistant professor, has been appointed assistant professor of government and executive director of the Southeast Asia Program at Cornell University.

●In the School of Medicine, Milton

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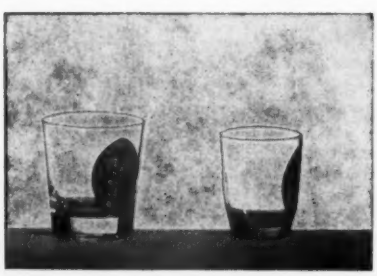


B. Kress, instructor in medicine, has been appointed acting superintendent and acting medical director of the Eudowood Sanatorium, Maryland.

A. Earl Walker, professor of neurosurgery, has been elected a vice president for 1951–52 of the American Neurological Association.

Helen Brooke Taussig, associate professor of pediatrics, was awarded an honorary doctorate of science by Columbia University.

Philip Bard, professor of physiology, recently delivered a series of lectures at the University of Chile under the Exchange-of-Persons Program of the Department of State.

Leo Kanner, associate professor of psychiatry and associate professor of pediatrics, recently gave two lectures in Mexico City for the Mexican Psychiatric and Pediatric Associations.

Grant E. Ward, associate professor of surgery, has been made an honorary member of the International College of Surgeons.

●At the School of Hygiene and Public Health, Howard A. Howe, adjunct professor of epidemiology, took part in the recent international poliomyelitis conference in Copenhagen.

●At the School of Engineering, Jean V. Lebacqz, assistant professor of electrical engineering, has left to work in the microwave laboratory at Stanford University.

●At the Applied Physics Laboratory, seven new members have joined the staff:

Jack W. Gebhard, former experimental psychologist at the University's Institute for Cooperative Research;

Perry J. Luke and Marshall C. Yovits, of Yale;

George G. Murray, Jr., of Harvard;

Oscar M. Martin, formerly with Yost Electronics Engineering Corp.;

George Wend, of St. John's College, Annapolis;

Walter G. Finch, taxation and patent attorney, formerly with the Roberts B. Larson firm, of Washington.

DR. ADAMS' DIPLOMA

In a previous issue, *The Johns Hopkins Magazine* reported that the Heidelburg diploma of Dr. Herbert B. Adams, first professor of history at Johns Hopkins, was presented to the University by Mrs. Mina H. A. Evans. Actually, the diploma was presented by Mrs. May Dickinson Kimball, a lifelong friend and relative of Dr. Adams; Mrs. Evans delivered it to President Bronk on Mrs. Kimball's behalf.

BOOKS BY HOPKINS MEN

Harry Bard, B.S. '29, g. '36–'37 (Educ.), and Harold R. Manakee, B.S. '41: *Active Citizenship.*

William Brody, lecturer in public health administration: *Personnel Administration in Public Health Nursing.*

Edward Hallett Carr: *German-Soviet Relations Between the Two World Wars 1919–1939* (Johns Hopkins Press).

Rachel Carson, M.A. '32 (Zool.): *The Sea Around Us.*

Edward M. Corson, '38–'40, Ph.D. '46: *Perturbation Methods in the Quantum Mechanics of n-Electron Systems.*

Paul Dolan, Ph.D. '50 (Pol. Sci.): *Organization of State Administration in Delaware* (Johns Hopkins Press).

William F. Hilton, Applied Physics Laboratory '46–'49: *High-Speed Aerodynamics.*

Herbert Hoover, LL.D. (hon.) '20: *Addresses Upon the American Road 1948–1950.*

Edgar Burke Inlow, Ph.D. '49 (Pol. Sci.): *The Patent Grant* (Johns Hopkins Press).

Isaac L. Kandel, fac. '31–'35: *Raising the School-Leaving Age: Studies on Compulsory Education.*

William Heard Kilpatrick, g. '91–'92, '95–'96: *Philosophy of Education.*

Frederic C. Lane, professor of history: *Ships for Victory* (Johns Hopkins Press).

Kemp Malone, Caroline Donovan Professor of English: *Chapters on Chaucer* (Johns Hopkins Press).

Adolf Meyer, late professor of psychiatry: *Collected Papers.* Vol. III (*Medical Teaching*); ed. by E. Winters; spec. ed., Franklin Ebaugh, B.A. '15, M.D. '19 (Johns Hopkins Press).

Raymond Durbin Miller, B.A. '98, Ph.D. '04, fel. '07–'08: *The Heresy of Jacob Hobbs.*

Wallace Judson Parks, g. '32–'35: *United States Administrations of Its International Economic Affairs* (Johns Hopkins Press).

Markham L. Peacock, Jr., Ph.D. '43 (Engl.): *The Critical Opinions of William Wordsworth* (Johns Hopkins Press).

Homer W. Smith, Sc.D. in Hyg. '21: *The Kidney: Structure and Function in Health and Disease.*

John M. Stephens, professor of education and professor of psychology: *Educational Psychology: The Study of Educational Growth.*

C. Vann Woodward, professor of American History: *Reunion and Reaction.*

Jack Engeman

Introducing Mrs. Silas Chang, a

NURSE WITH AN IDEA

LAST spring Mrs. Silas Chang visited an elderly woman who was a diabetic patient. The visit was routine, one of many which Mrs. Chang made during the public health period of her training in the Johns Hopkins School of Nursing. She had seen the patient before, but this time she noticed that the woman seemed sicker, worse off than her case history warranted. Mrs. Chang investigated and found that the patient had been giving herself the wrong dosages of insulin. She had poor eyesight and had been unable to read the numbers which served as a gauge on the barrel of her syringe-injector. Since she could not see how far back to pull the plunger which drew insulin into the syringe, the woman was making mistakes and giving herself too much or too little at one dose.

Mrs. Chang discussed the patient's difficulty with other nurses; she found that they, too, had experienced the same problem with older diabetic patients. One nurse suggested tying a black thread around the barrel at the spot where the tip of the plunger should stop; since the barrel is translucent, the patient could see when the plunger reached the black line of the thread, rather than have to make out the small white numerals.

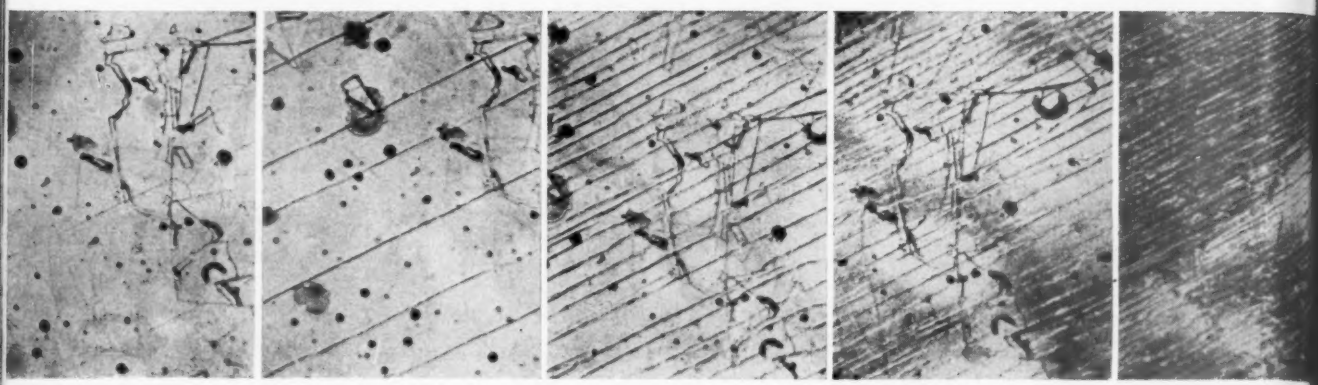
Mrs. Chang tried this; but the thread slipped with handling. She reasoned that something stiffer might work—wire, perhaps. She made an experimental attachment, had it approved by her supervisor in the Dispensary Visiting Nurse Service, and gave it to her patient. The patient found that she could then measure accurate dosages with ease and certainty.

In September this simple but ingenious device was chosen as one of the ten best ideas in the American Hospital Association's annual "What's an Idea Worth?" competition. It is expected to be of great value among elderly diabetic patients, who frequently have poor eyesight.

Mrs. Chang's career as a student nurse began in 1940 in Peking, China, at the Peking Union Medical College School of Nursing (founded by Miss Anna D. Wolf, present director of the Hopkins School). The school was closed by the Japanese, but in 1948 Mrs. Chang came to this country. She spent one year on a fellowship at Princeton Theological Seminary and then, in 1949, started her training in the Hopkins School of Nursing. She received her degree in September and will work in Texas where she has gone to join her husband.

What Is A Metal?

Continued from page 11



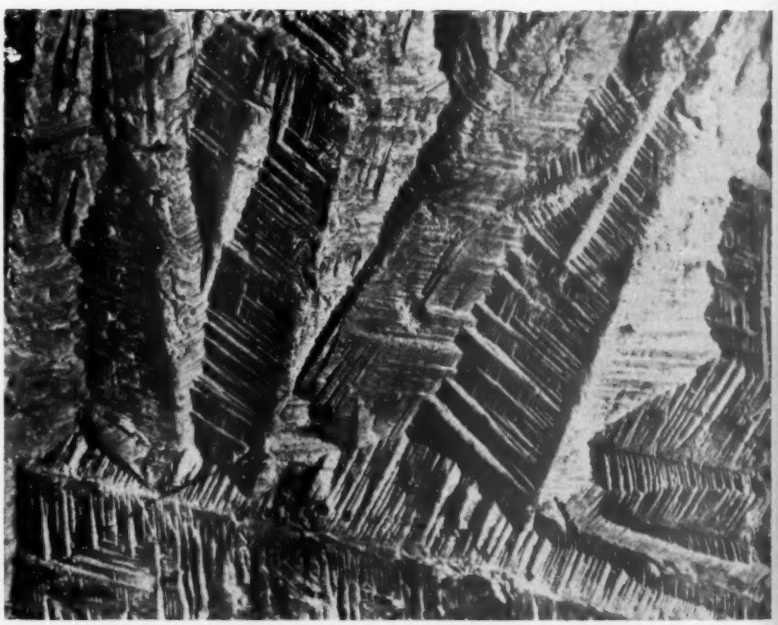
3 **FORMATION OF LINES OF GLIDE** can be watched with apparatus designed by Professor R. B. Pond. These high-speed photographs show the progressive formation of lines during the extension of a single crystal of aluminum. The figures indicate film frame numbers, this sequence covering about two and a half seconds of the action.

vestigated in still another way. Professor R. B. Pond, of the Hopkins metallurgy section, has developed a small hydraulic tensile apparatus. With this equipment it is possible to extend small single crystals on the stage of a metallograph, so that the deformation can be observed at high magnifications while it is going on. Stress and strain are being measured at the same time that high speed motion pictures are taken at high magnifications.

An example of some of the results by this method may be seen in figure 3. The material here is a small single crystal of aluminum grown to a particular shape and treated so as not to introduce any strain before the documented deformation. There, the progressive formation of lines of glide may easily be seen. This work, sponsored by the Office of Air Research, has uncovered many basic facts which have aided in the overall picture of the plasticity of metals.

A VERY basic problem being studied at Hopkins is the manner by which metals solidify. The transformation from liquid to solid almost always produces a characteristic tree-like structure called a dendrite. An example of the appearance of a dendrite may be seen in figure 4.

In order to control certain variables in this investigation, molds of copper were specially designed. The molds, coated on the inside with a very thin layer of graphite, are set into a talc block over a nichrome heating coil. Percussion-welded to the bottom of the mold at each quarter inch position are iron-constantan thin wire thermocouples, whose leads are passed out through the talc into an ice-water cold junction. From there, they are connected to a battery of microammeters. The copper boat is welded to a copper cooling block which is connected to a copper pipe used as a conveyance for cooling media.



4 **A TREE-LIKE STRUCTURE** called a dendrite is characteristically produced when liquid metal hardens. Hopkins researchers are trying to explain their formation.

High purity tin is melted in the mold and solidified, using different cooling media. The temperature gradient above the melting point and during the solidification process is carefully recorded by photographing the meters and a stop watch as the solidifying interface (visible on the surface) passes the thermocouple stations. In this manner, a carefully documented time-temperature relation is obtained. The orientations of the resulting grains are determined either by x-rays or by optical goniometry. By carefully controlling the heat input, equilibrium between a solid-liquid interface has been maintained for periods as long as four hours.

CAREFUL metallographic study has resulted in a theory for the mechanism of growth of the dendrite form in metals. The dendrite or tree-like form is seen on the surface as longitudinal striae, as seen in figure 5, aligned almost parallel to the direction of growth of the grain. These observations are, of course, made on the surface of a solidifying liquid.

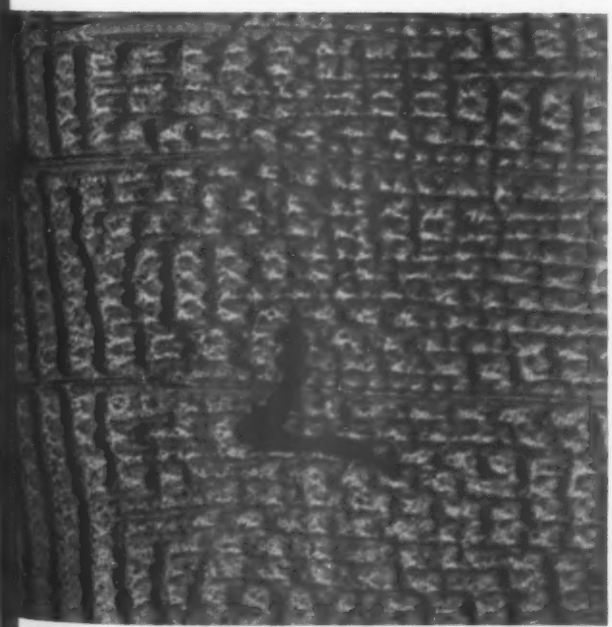
For a three dimensional picture of the dendrite, it is desirable to obtain an end view of the growing metal. This is accomplished by connecting a vacuum pump to a glass tube in the solidifying liquid. At any desired time and position of the liquid-solid interface, the liquid can be removed almost instantaneously by connecting the vacuum, thus leaving the bled solid interface. In this manner the end view of these longitudinal striae can be studied. Figure 6 and the photograph on page 9 show the network of hexagons characteristic of solidifying metals.

PROFESSOR Pond's explanation for the growth of the hexagons, which he has termed mammiforms, is based upon an analysis of the thermal gradients and thermal diffusion. A mechanism has been constructed by which it is possible to explain the characteristic shape of dendrites. In brief, the nuclei of mammiforms are deposited at positions on a growing face. Because of heat dissipation along the surface, into the liquid, and back into the solid, the positions of these nuclei are symmetrical. The growth into their characteristic shape is determined by the heat dissipation and diffusivity of impurities. In a similar manner, the tree-like appearance of the dendrites is explained.

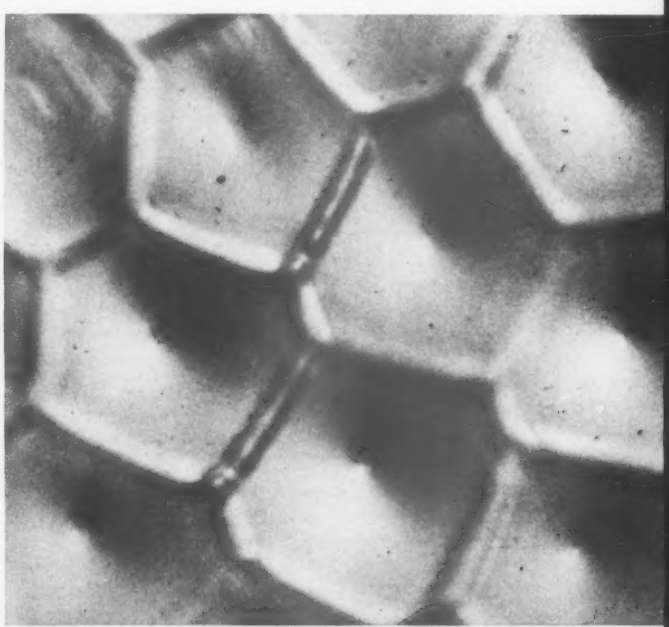
Research recently completed at Hopkins by Dr. I. R. Kramer was concerned with the measurement of delay time for the initiation of glide in single crystals of alpha brass, aluminum, and beta brass. Dr. Kramer constructed a pendulum which permitted the crystals to be subjected to a constant stress for various periods of time. He found a delay time for glide in the body centered cubic beta brass when the specimens were tested below room temperature. No delay time, however, was found for the face centered cubic metals, alpha brass and aluminum, at temperatures as low as $-190°C$ for impact times as small as 8×10^{-5} seconds.

From these findings, he is able to explain why the body centered cubic metals fail in a brittle manner below a certain temperature and fail in a ductile manner above this temperature (brittle transition temperature), whereas the face centered cubic metals do not behave in this manner. This theory proposes that the existence of a delay time for the initiation of glide will permit a specimen to be loaded at a rate sufficiently rapid so that the delay time is not exceeded. If, under these conditions, the stress is sufficiently high to cause fracture, plastic deformation cannot occur and the specimen must fail by cleavage.

THE importance of metallurgy in today's world needs no great emphasis. The need for metals which will withstand extremes in temperature and also have thousands of special properties and applications has necessitated fundamental investigations of the solid state. The Hopkins metallurgy research program together with the graduate activities in metallurgy is making substantial contributions to the better understanding of the solid state.



5 THE SURFACE of solidified tin, magnified sixteen times, shows dendrite arms in the form of striae.



6 THE ENDS of the dendrite striae, photographed as they are being formed in the metal, are typically hexagonal.

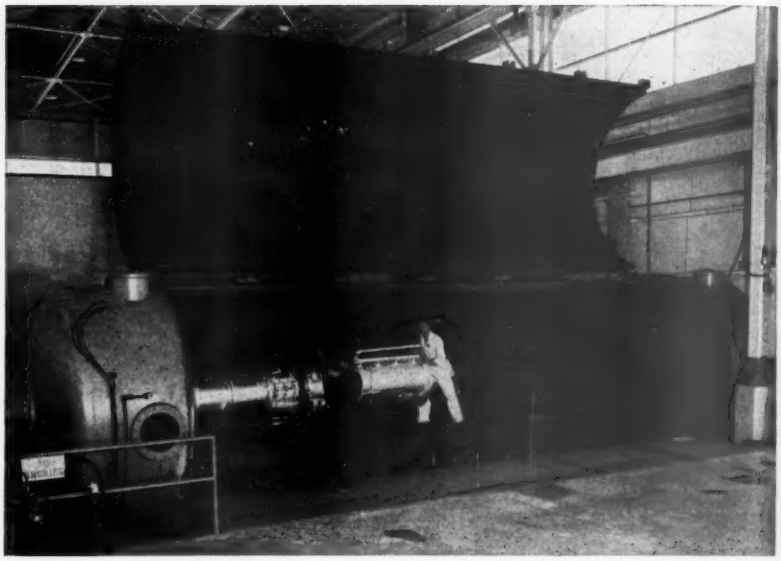
Guided Missiles

Continued from page 8

missile must carry in order to perform properly under this system is fairly simple: only enough to receive and obey the commands from the ground. It does little or no thinking for itself; it may be called a "moron," although the missile's master on the ground, the radar and the rapid-computing devices, are far from the moronic level.

The second general guidance system is the way-following system, illustrated on Page 7 by the beam-rider missile. Way-following involves setting up an artificial path in space for the missile, such as a radar beam, originating near the missile's launching platform, which tracks the target. The missile has a mechanism which orients it constantly to the axis of this artificial path; when it deviates, it corrects its course accordingly. Much more complicated and intelligent than the command-guided missile, the way-follower or beam-rider may be thought of as the "conscience" type — its conscience twits it, and makes it go straight, when it begins to stray. Many missiles may ride the same beam.

The third type of missile is directed to its target by "homing guidance," and its intelligence must be still higher than that of the beam-rider. It receives its directional signal straight from its target and adjusts its own course to effect a collision. It recognizes its quarry and goes after it. In the terminal phase of the missile's course, this system offers great accuracy; but range restrictions are considerable. Homing guidance, therefore, is usually used in conjunction with other systems for guiding the missile in the early and middle phases of its flight.

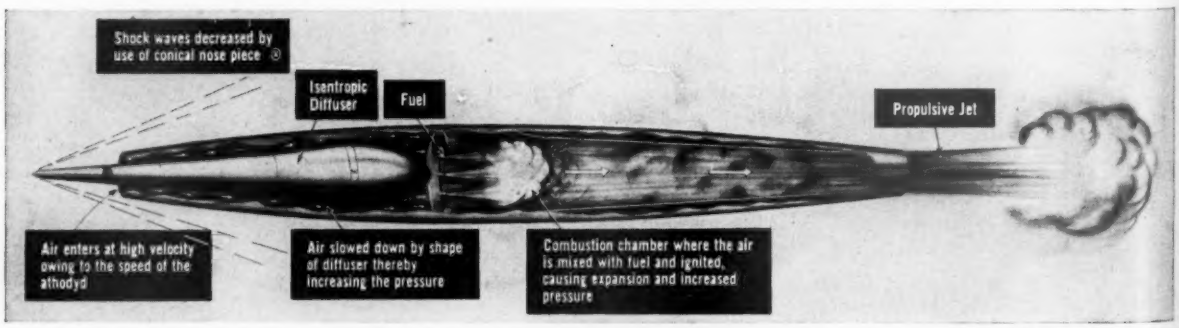


Consolidated-Vultee Aircraft Corporation

HIGH-ALTITUDE TEST CHAMBER at Daingerfield, Texas, makes it possible to test large-scale ram-jet engines at simulated altitudes of approximately twenty miles above the earth—and at four times the speed of sound. Engineering for the chamber—and also the operation of it—has been carried out by Consolidated-Vultee Aircraft Corporation, under technical direction of the Hopkins Applied Physics Laboratory.

Fourth, a missile may adjust its own course—i.e., navigate—so as to follow a predetermined route from its launcher to its target. This is a tough assignment; reliability and accuracy in a system such as this are difficult things to achieve. But this will probably, according to scientists who have written about this method in recent years, be the guidance method employed in long-range missiles. It may use, as its navigational guide, such a natural frame of reference as the stars or the direction of the vertical, or an artificial frame of reference such as the electromagnetic network of Loran. Under this system falls the dead-reckoning system, in which the frame of reference is defined in inertial space by gyros and in which the motion of the missile is followed by accelerometers. Again, a knowledge of the vertical would be necessary on the missile's part.

In controlling guided missiles, stability of flight—avoiding sharp turns or large oscillations around the correct path which the missile should follow—is of prime importance. It is similar to the necessity, in driving a car or even a bicycle, of instinctively adjusting one's steering in order to correct one's deviations from the right course. To study the flight stability of missiles, the scientists have devised special computing machines called "flight simulators." Into them are fed such data as aerodynamic coefficients, and parameters of the electrical circuits and the servo-mechanism. The computers pro-


Shock waves decreased by use of conical nose piece
Isentropic Diffuser
Fuel
Propulsive Jet
Air enters at high velocity owing to the speed of the athodyd
Air slowed down by shape of diffuser thereby increasing the pressure
Combustion chamber where the air is mixed with fuel and ignited, causing expansion and increased pressure

Illustrated London News

ARTIST'S VIEW OF A SUPERSONIC RAM-JET, MOVING RAPIDLY THROUGH THE AIR AFTER "BOOST" TO VELOCITY

duce a curve or curves showing the type of trajectory the missile will fly. Or other information, determining the probability of success of an actual flight, can be obtained from the machines. In a single morning, a research scientist can complete studies with the aid of the computers which would otherwise require the flying of fifty to a hundred actual missiles.

"Broadly speaking," observes Dr. Gibson, "the guidance problem is in the forefront of man's attempt to endow his guided-missile creatures with more sensitive, more versatile, and more responsive intelligence, and with more reliable and stronger sinews to translate this intelligence into action—a quest which extends his ingenuity to the utmost."

GETTING a missile to move is in itself a problem of tremendous magnitude. Generally, two propulsion methods must be used: the auxiliary propulsion system, or "booster," which accelerates the missile to its design speed, and the main propulsion system, which maintains it at this speed once it is reached. Both are necessary to gain and maintain the high speeds characteristic of the supersonic guided missile, to give it flexibility and surprise in attack, and to endow it with invulnerability in defense.

Heavy power plants must be avoided, however; they impose a heavy penalty with their great weights: drag, associated with the extra lift needed to support them, is increased badly. The German V-2, which was propelled from its launcher by its main propulsion system, carried such a heavy power plant; but since it flew a ballistic trajectory and did not need to maneuver or be guided in its flight, and since its speed at launching was not important, its weight was not critical. Modern missiles, to satisfy the guidance requirements laid down by today's defense problems, can afford no such luxury.

Jet engines, most people know, are the answer. Of jets, there are four main types: turbo-jets, pulse-jets, ram-jets, and rockets. Rockets—both solid-fuel and liquid-fuel rockets—and ram-jets are, in the present state of supersonic-engine development, regarded as most usable. And, generally, solid-fuel rockets (being simple machines) may be said to be preferable for very short-range missiles; liquid-fuel rockets are applicable in middle ranges; and ram-jets are preferable (except in ballistic-trajectory missiles) for longer-range weapons.

RAM-JETS have long been an APL specialty. The principle of ram-jets is not new; it had been known as early as 1913. But little had been done with it until World War II, when APL tackled the problem. There were no available means of launching the ram-jet engine to operating speed; it must be moving at a great velocity in order to work.

In January, 1945, in view of recent advances in rocket propulsion, APL decided that design of a successful ram-jet was now feasible. The establishment of this project at APL at that time was the start of APL's special interest in guided-missile development. The project was code-named "Bumblebee." Just five months later, on June 15, 1945, a ram-jet engine operated successfully in free flight. It was the world's first supersonic ram-jet engine.

On Page 30 is an artist's conception of a supersonic ram-jet in flight. The reader will find it helpful to refer to the picture during the following explanation of its operation (presented in Dr. Gibson's words):

"The vehicle is moving rapidly through the air, having been boosted to velocity by an auxiliary propulsion system. The dynamic pressure set up by the relative motion of the missile and the atmosphere causes air to enter through the intake into a diffuser where the velocity is reduced and the pressure and temperature are raised. Near the exit of the diffuser, fuel is injected into the air stream; mixing takes place; and the whole moves into the combustion chamber where ignition occurs, the fuel burns, and the temperature of the gases rises sharply. The burning gas attempts to expand in all directions—the walls constraining it to move parallel to the longitudinal axis.

"Expansion toward the forward end occurs; this slows down the incoming stream and produces further rise of the pressure in the diffuser. This pressure reacts on the sloping walls of the diffuser, giving a forward thrust to the vehicle. Depending upon the forward speed of the ram-jet and the design of the diffuser, this pressure reaches a limiting value and, when this is reached, we may presume that the pressure is high enough to hold back the hot gases and to force them to move in the only other direction possible—toward the exhaust."

The ram-jet has been nicknamed the

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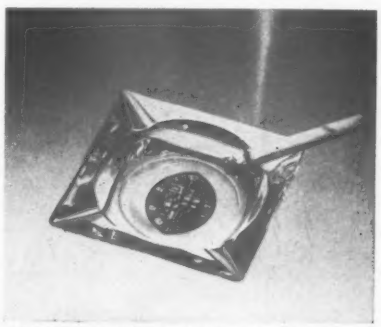

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THE MONTH
at Johns Hopkins

A calendar of events: October 20—November 30

DRAMA

DON JUAN IN HELL (by George Bernard Shaw)—With Charles Laughton, Charles Boyer, Sir Cedric Hardwicke, Agnes Moorehead; Mon., Oct. 29, Lyric Theatre; curtain 8:30 p.m. Sponsored by the Johns Hopkins Playshop. Single admission, $3.62, $3.02, $2.41, $1.81, $1.21. Tickets may be obtained from the Bonney Concert Bureau, 327 N. Charles St., Baltimore 1, Md.; LExington 3100.

DEIRDRE OF THE SORROWS (by John Millington Synge)—Nov. 13–17, Hopkins Playshop, Homewood; curtain 8:30 p.m. Single admission, $1.20; subscription price to the three plays of the Playshop's 1951–52 series, $3.00. Tickets may be obtained from the Johns Hopkins Playshop, The Johns Hopkins University, Baltimore 18, Md.

VARSITY SPORTS

NOTE—No admission fee is charged at any Johns Hopkins home athletic events. Persons who wish to attend Hopkins games during the 1951–1952 University year may obtain a free season ticket by sending a stamped, self-addressed envelope to the Department of Physical Education and Athletics, the Johns Hopkins University, Baltimore 18, Md. Alumni should address their requests to the Alumni Relations Office, the Johns Hopkins University, Baltimore 18, Md.

FOOTBALL—Johns Hopkins vs. Randolph-Macon, Sat., Oct. 20 (Homewood Field, 2 p.m.); Gettysburg, Sat., Oct. 27 (Homewood Field, 2 p.m.); Swarthmore, Sat., Nov. 3 (away); Dickinson, Sat., Nov. 10 (away); Western Maryland, Sat., Nov. 17 (Homewood Field, 2 p.m.).

SOCCER—Johns Hopkins vs. Franklin-Marshall, Sat., Oct. 20 (Homewood, 12 noon); Drexel, Wed., Oct. 24 (away); Western Maryland, Sat., Oct. 27 (away); Washington, Thurs., Nov. 1 (away); Maryland, Wed., Nov. 7 (Homewood, 3 p.m.); Delaware, Sat., Nov. 10 (Homewood, 2 p.m.); Loyola, Sat., Nov. 17 (Homewood, 12 noon).

CROSS-COUNTRY—Johns Hopkins vs. Washington, Sat., Oct. 20 (Homewood, 2 p.m.); Catholic, Tues., Oct. 23 (away); Delaware, Fri., Oct. 26 (away); Loyola, Wed. Oct. 31 (Homewood, 4 p.m.); Swarthmore, Sat., Nov. 3 away); Middle Atlantic Championships, Fri., Nov. 9 (away, at Muhlenberg); Mason-Dixon Championships, Sat., Nov. 17 (away, at Gallaudet).

TELEVISION

The Johns Hopkins Science Review is being carried by eighteen stations:

Ames, Iowa: WOI	*New Orleans: WDSU
Baltimore: WAAM	New York: WABD
*Boston: WBZ	Omaha: KMTV
Chicago: WGN	Rock Island: WHBF
Cleveland: WXEL	*Salt Lake City: KSL
Columbus: WTVN	*San Antonio: KEYL
*Dallas: WFAA	*San Francisco: KPIX
*Houston: KPRC	Schenectady: WRGB
*Los Angeles: KTTV	Washington: WTTG

*In these cities, consult newspapers or call the stations for day and time of program. In other cities, broadcast time is Mondays, 8:30 p.m., EST.

ALUMNI MEETINGS

OHIO VALLEY ALUMNI MEETING—Fri., Nov. 9, University Club, Cincinnati, at 8 p.m. (postponed from Sept. 28). Oysters, rushed from Chincoteague, will be a feature.

COMING EVENTS

HALSTED CENTENNIAL—Events marking the one hundredth anniversary of the birth of William S. Halsted, first professor of surgery at Johns Hopkins. Meetings in Hurd Hall, Feb. 6–9.

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"flying stovepipe"—but it is not quite that simple. It has no moving parts, no complicated mechanical devices. But its design requires a thorough and detailed command of complex gas-flow principles, mixing phenomena, and ignition and combustion processes under extremely high rates of flow. Before such an engine could be made to work, enormous quantities of empirical and experimental work went into its design. Only an organization like APL, where university scientists and engineers work hand-in-hand not only with other scientists but also with Naval and industrial experts, could have turned it out with only five months' labor.

SO FAR, this article has spoken of guided missiles only in terms of their use as weapons of war. What contributions can they make in peace?

Solid-fuel rockets already have their peacetime applications. JATO—the jet-assisted takeoff of airplanes—is one such use. Liquid-fuel rockets have enabled scientists to learn more about the upper atmosphere—information which, as articles in earlier issues of *The Johns Hopkins Magazine* have shown, had previously been inaccessible to man. Ramjets—simple, expendable, fast—may, if man wishes to pay the price for high-speed transportation, have their peacetime applications.

DESPITE all this, one must guard against expecting miracles. Let Dr. Gibson express it:

"The realistic thinker will not expect revolutionary changes in military and technical thought and outlook from the development of guided missiles. He will remember that experience has taught reliance on evolutionary processes for positive progress. It has taught us that the way to great achievements is through the step-by-step solution first of scientific problems and then of engineering ones.

"Scientific principles now established indicate that satellite vehicles, interplanetary rockets, or full-scale 'push-button warfare' is not at all fantastic. However, wisdom dictates that we first shall exploit to the fullest extent unguided rockets, ballistic rockets, and fully-guided missiles, which have a big role to play now and in the future; and that, by doing so, we shall be furnished with skill and knowledge to attack the larger problems when the necessity arises."

Robert M. Mottar

NEXT MONTH

Sometime next summer, a great bridge will be opened across the Chesapeake Bay, linking Maryland's Eastern and Western Shores for the first time. The bridge is one of man's mighty achievements: it is over four miles long from shore to shore, more than seven miles long over-all. Its structure soars to a height of 354 feet above the water at its highest point, and its piles extend as deep as 203 feet below the surface of the Bay. A picture story of the building of the Chesapeake Bay Bridge, as seen through the eyes of two Hopkins engineering graduates who are supervising its construction, will appear in the December, 1951 issue of

THE JOHNS HOPKINS MAGAZINE

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Class of 1978 . . . ?

When John Smith, of the Class of 1918 received his diploma, his four years of college—tuition, dormitory room, board, books and other expenses—cost him about $850 per year or a total of $3,400.

When John Smith, Jr. appeared on the scene, the proud father decided that Junior, too, would have a college education, and through a plan of saving and insurance created an "education fund" of $3,500 that would be available when Junior reached college age.

Everything went according to plan except the cost of the college education! Like all costs, it had risen, and the total cost for the 1948 graduate was about $7,600.

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